Robot Technology Development
Perception, User Interfaces and Architecture

Terry Fong

Intelligent Robotics Group
NASA Ames Research Center
**terry.fong@nasa.gov**

irg.arc.nasa.gov

Intelligent Robotics Group (IRG)

Overview

- 31 researchers (14 Ph.D.'s)
- 20+ summer interns yearly
- 75% NASA work (HEOMD, STMD, SMD)
- 25% reimbursable (Google, etc.)
- SBIR / STTR (10 current proj.)

Research themes

- **Automated planetary mapping**
  - Base maps & terrain models
  - Geospatial data systems
- **Robots for human explorers**
  - Improve efficiency & productivity
  - Pre-cursor & "follow-up" work
- **Public service**
  - Disaster response & outreach
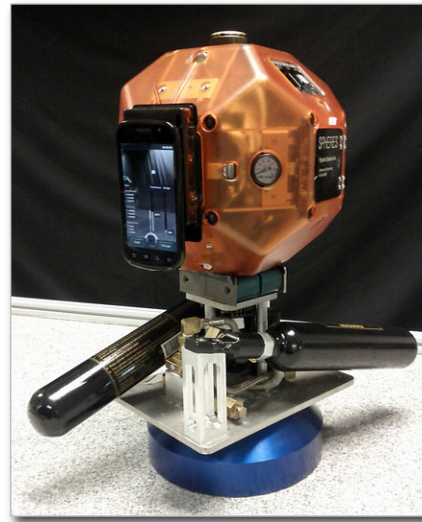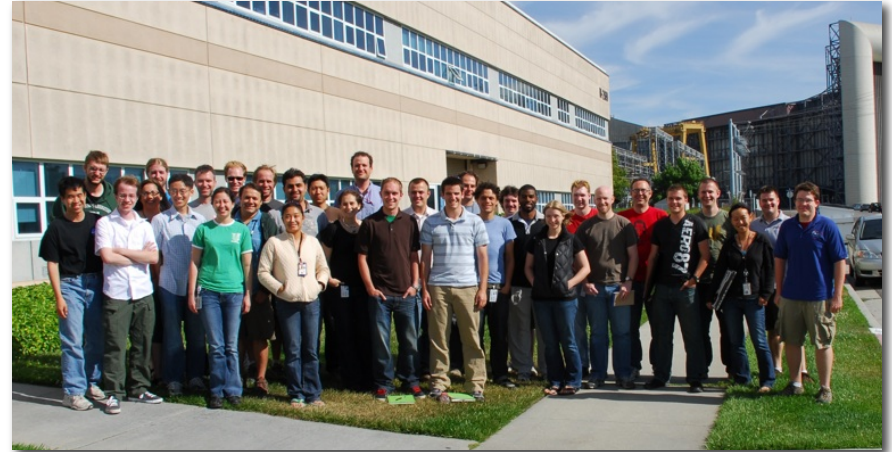
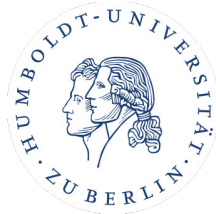

irg.arc.nasa.gov

IRG Collaborations (2010-2013)

Academic

THE ROBOTICS INSTITUTE

Massachusetts Institute of Technology

ARIZONA STATE UNIVERSITY

University of Idaho

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

HUMBOLDT-UNIVERSITÄT ZU BERLIN

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

SETI INSTITUTE

KAIST Korea Advanced Institute of Science and Technology 한국과학기술원

Commercial

Google

Microsoft Research

Aurora FLIGHT SCIENCES

Microcosm Inc

Stottler Henke Smarter Software Solutions

ENERGID

HONEYBEE ROBOTICS

Optech

TRAC Labs

PI ProtoInnovations

PRCI

Government

SPAWAR

CAL FIRE SINCE 1885

CALIFORNIA TASK FORCE 3 U·S·&R URBAN SEARCH AND RESCUE

USGS science for a changing world

Robotics for Human Exploration

Purpose

- Increase human productivity
- Improve mission planning & execution
- Transfer **some** tasks to robots (tedious, repetitive, long-duration)
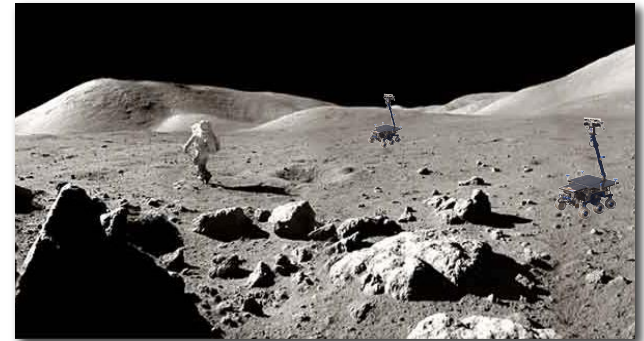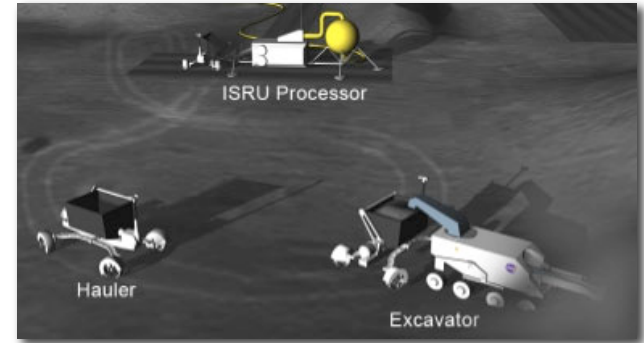
Before Crew

- Recon (scouting) & prospecting
- Site prep, deploy equipment, etc.

Supporting Crew

- Inspection, mobile camera, etc.
- Heavy transport & mobility

After Crew

- Follow-up & close-out work
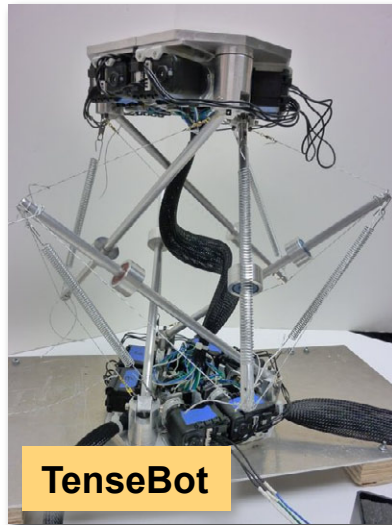- Site survey, supplementary tasks, etc.

Robots

K10 mini

K10

KREX

TenseBot

Modular Arm
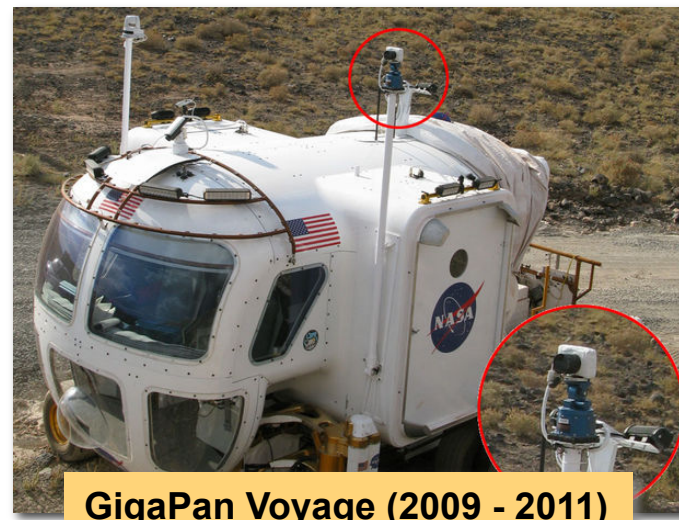
Smart SPHERES

GigaPan

Lake Lander

Perception

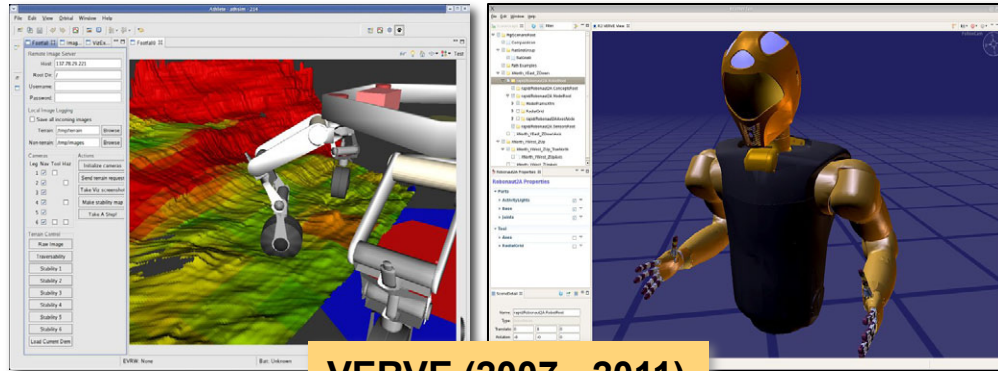High Dynamic Range inspection (2006)
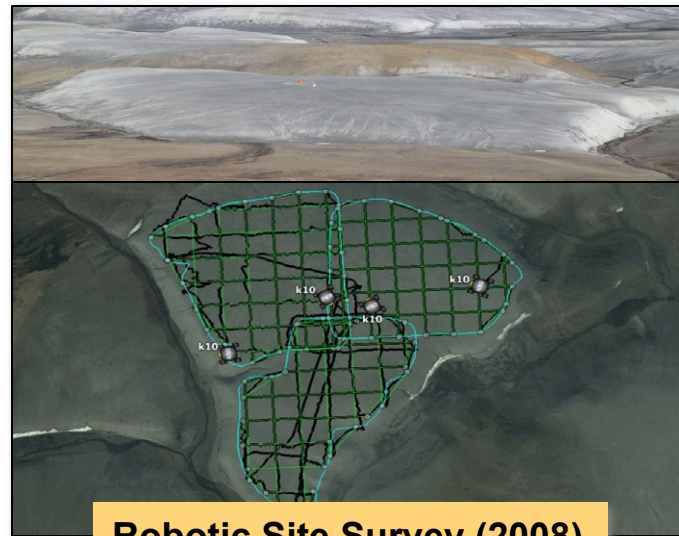
Robotic Site Survey (2008)
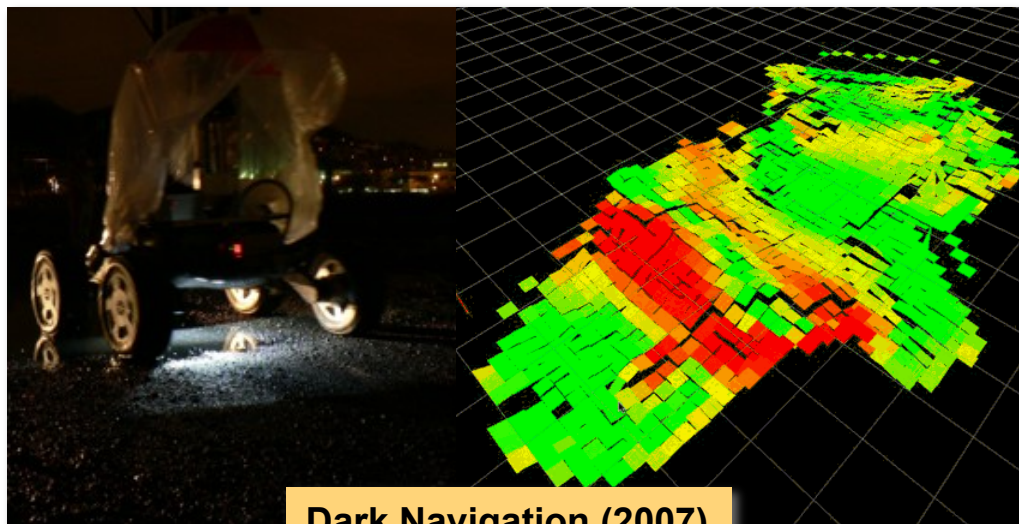
Dark Navigation (2007)

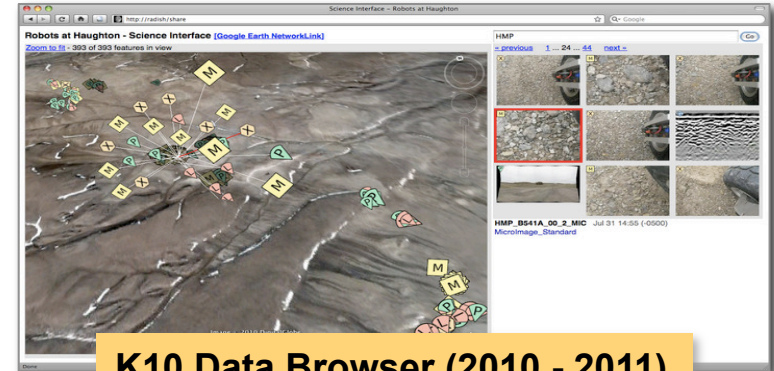
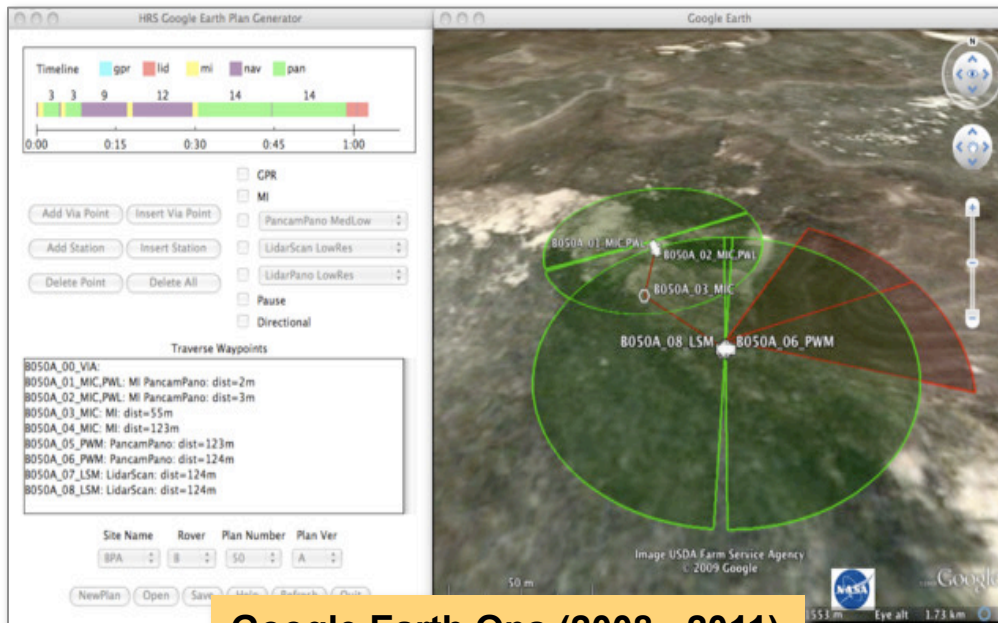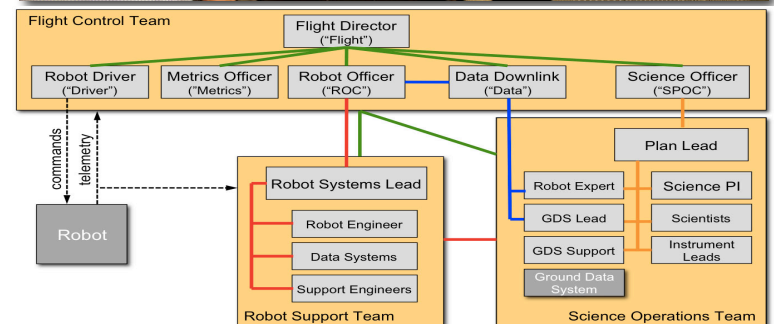GigaPan Voyage (2009 - 2011)

User Interfaces

VERVE (2007 - 2011)

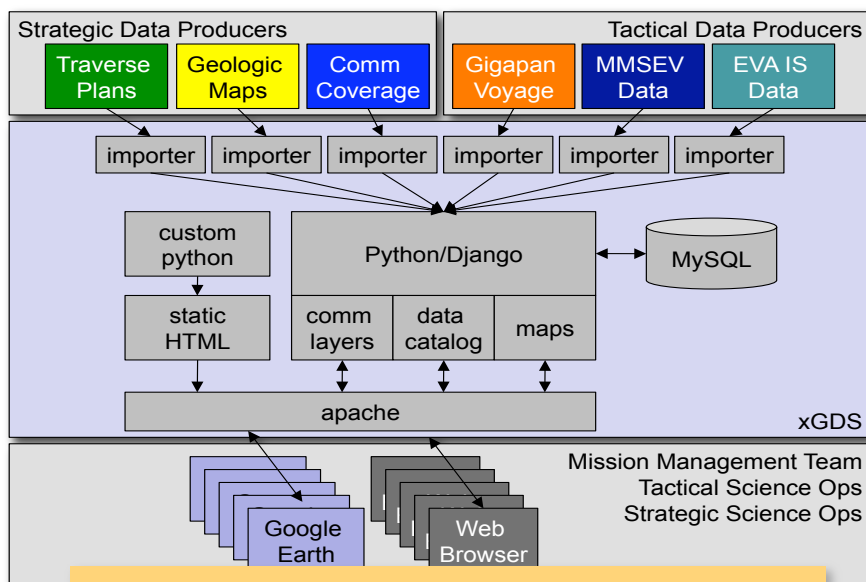**K10 Data Browser (2010 - 2011)**
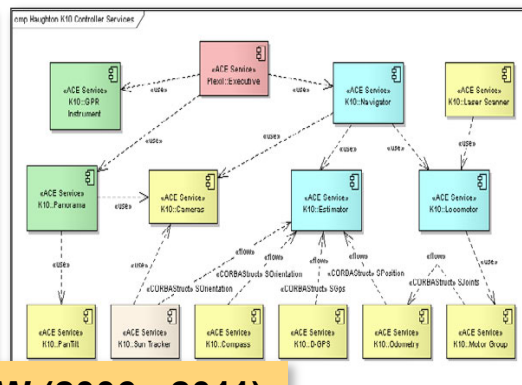

Google Earth Ops (2008 - 2011)

Interactive Ground Control (2008 - 2010)

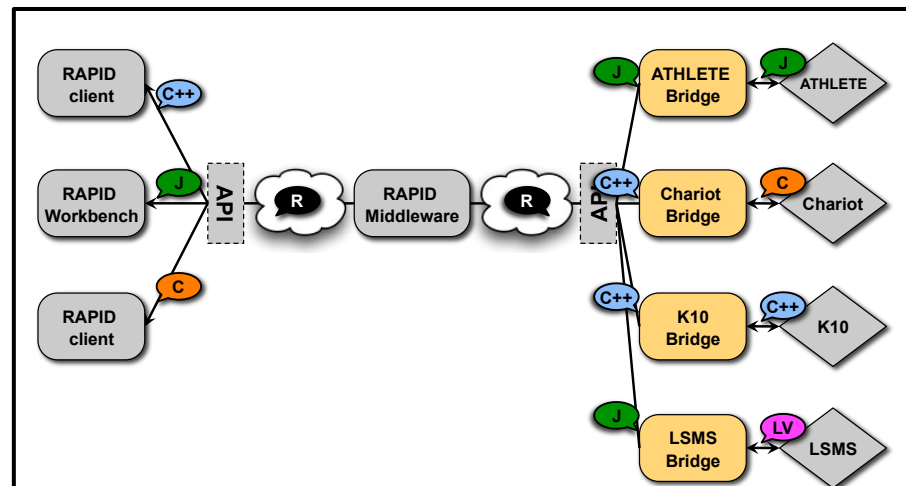*Intelligent Robotics Group*

Architecture

RoverSW (2006 - 2011)

xGDS: Exploration Ground Data System (2009 - 2011)
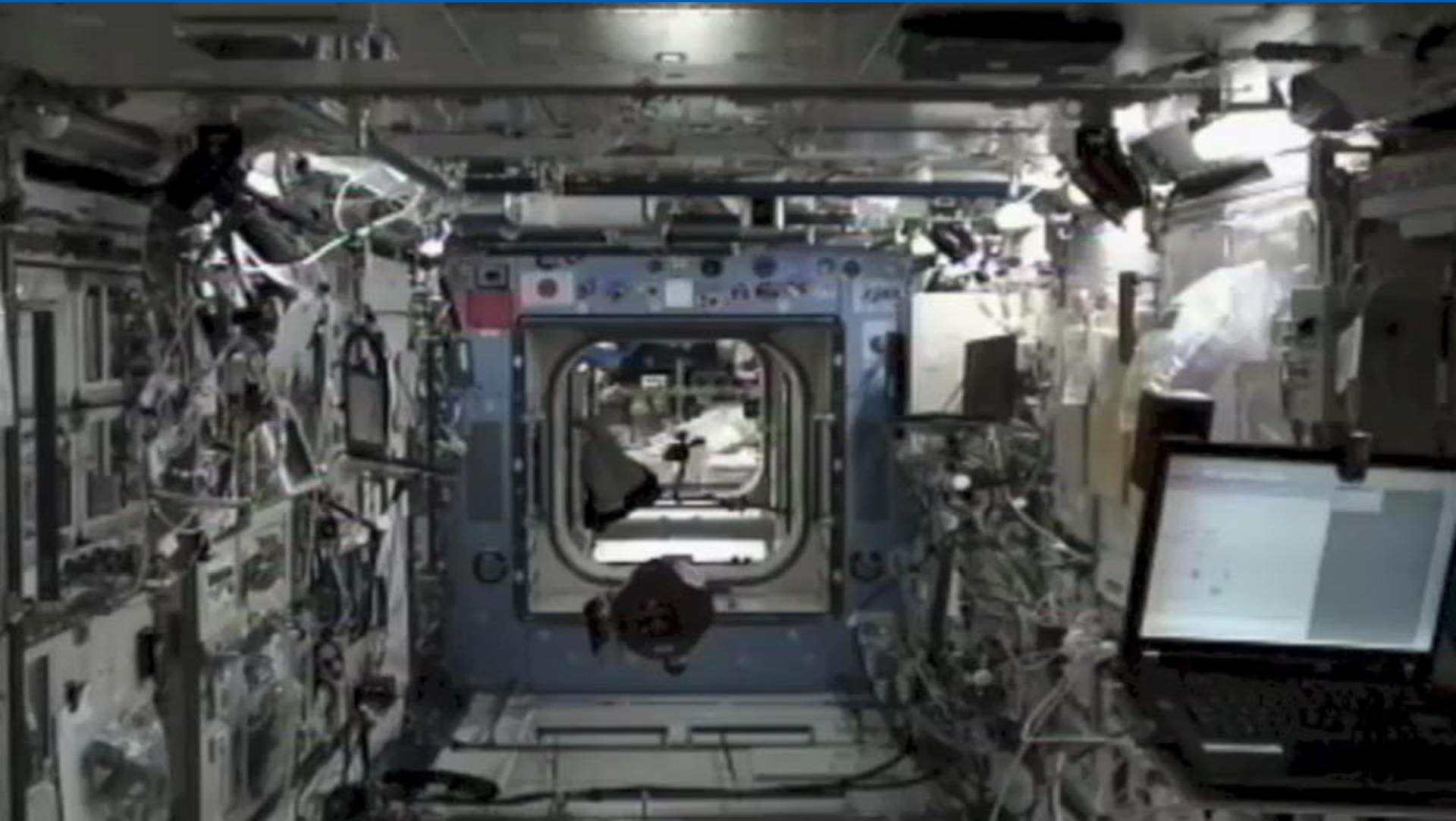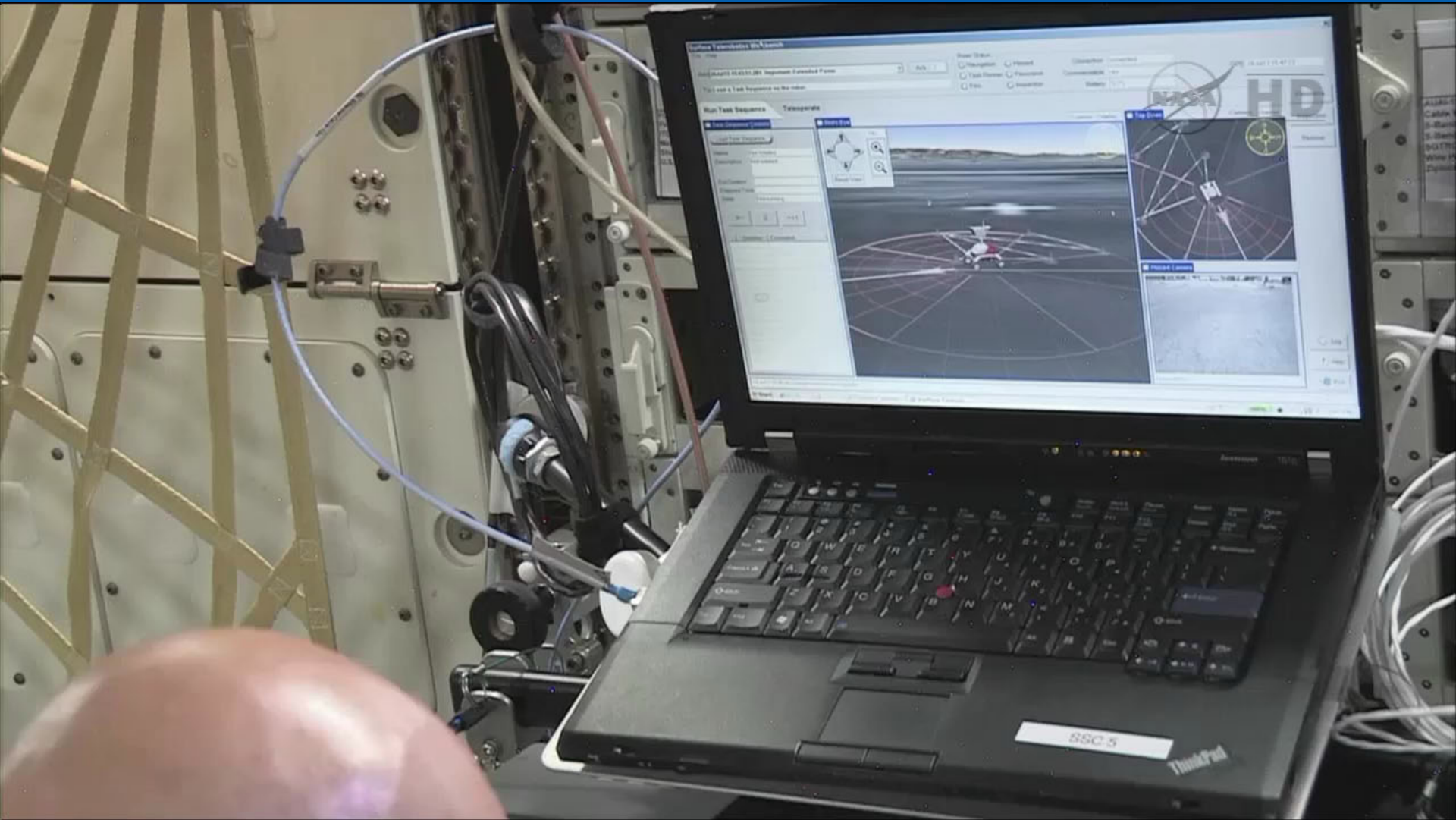

RAPID (2009 - 2011)

K10 Robot at Haughton Crater, Canada

SmartSPHERES on ISS
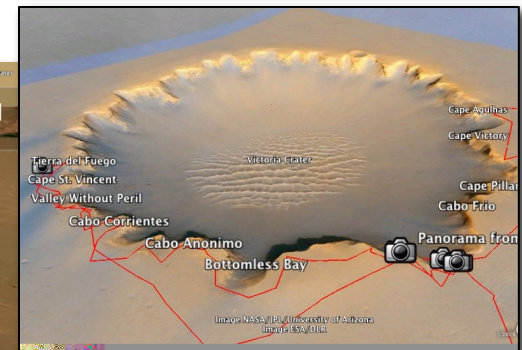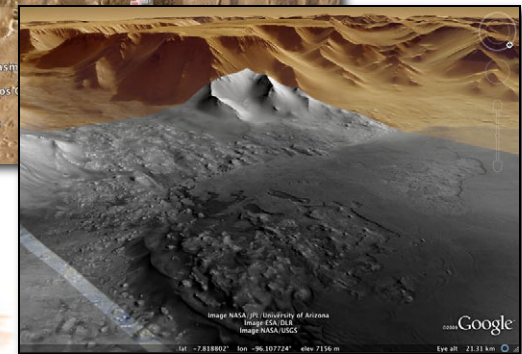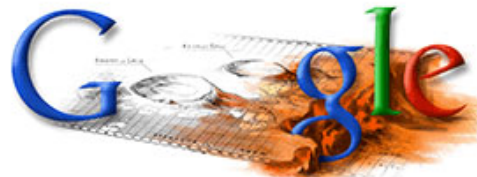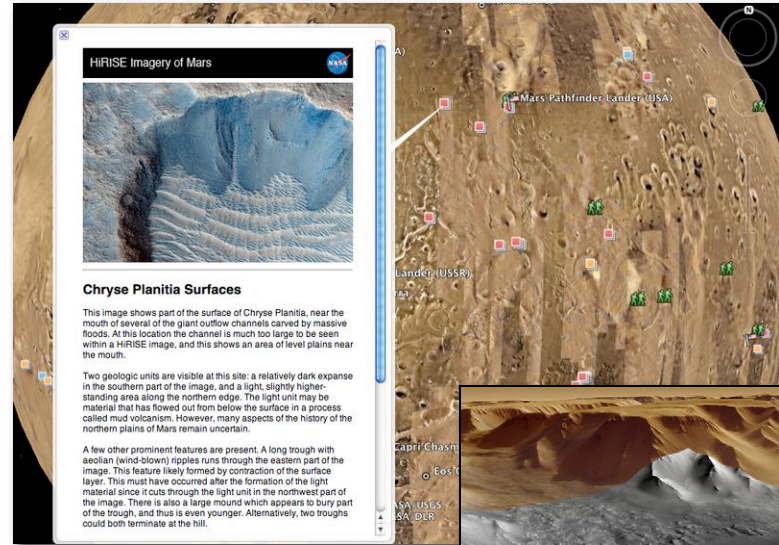
K10 Remotely Operated from ISS

Mars in Google Earth

Explore Mars in 3D

- Released Feb. 2, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content

- Global maps: topography, infrared, historical, etc.
- Imager footprints & overlays (HiRISE, CTX, MOC, …)
- Mars rover tracks & color panoramas
- Tours (Bill Nye & Ira Flatow)
- Live from Mars: THEMIS
- And much more …

Moon in Google Earth

Explore the Moon in 3D

- Released July 20, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content

- Global maps: topography, geologic, historical, etc.
- Spacecraft imagery: Apollo, Lunar Orbiter, etc.
- 3D models of spacecraft, landers, and crew rovers.
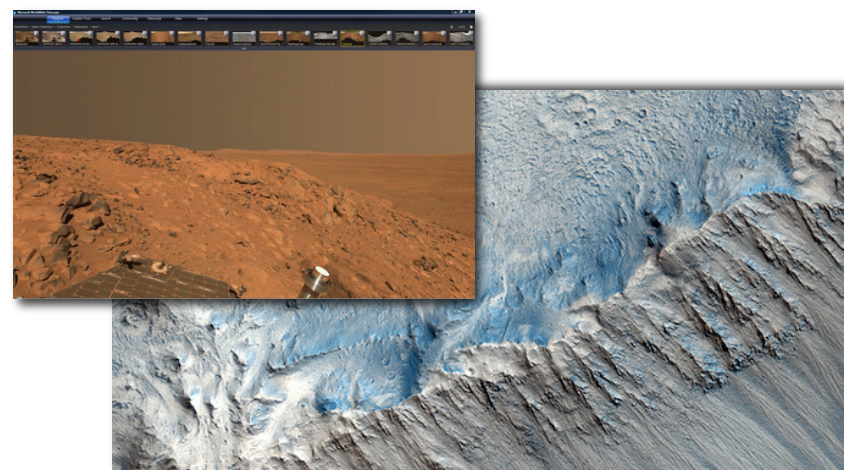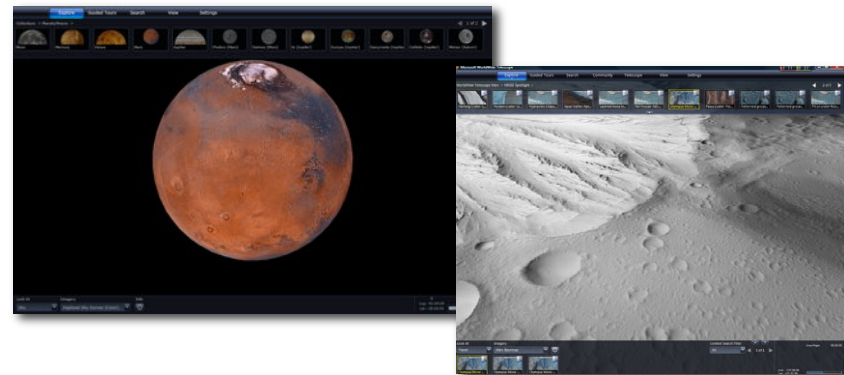- Tours (Andy Chaikin, Buzz Aldrin & Jack Schmidt)
- And much more …
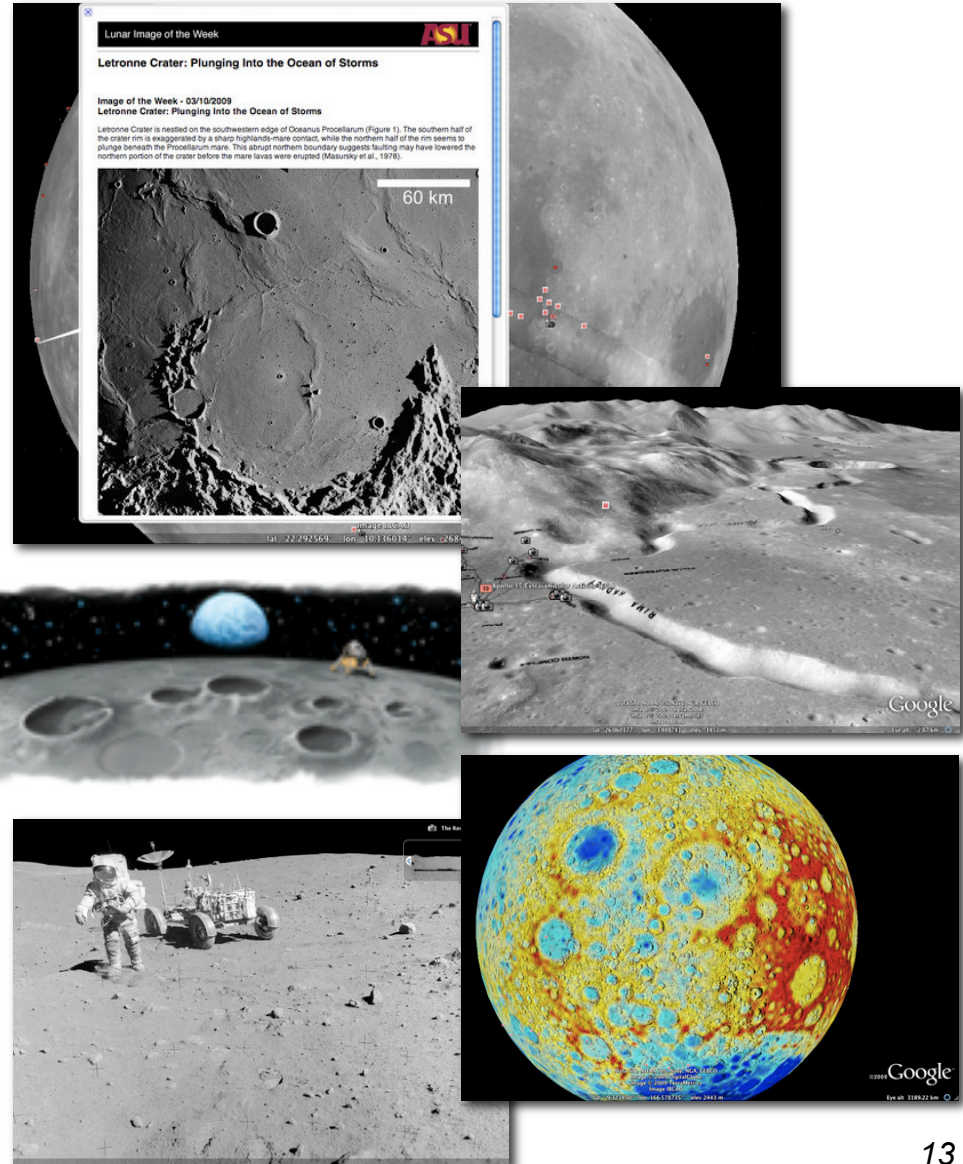
WorldWideTelescope | Mars

Complete HiRISE Mosaic

- Mars Reconaissance Orbiter HiRISE imager
- 74,000 images
- Each image: 20K x 50K pixels (> 1 GB / image)

Mosaic stats

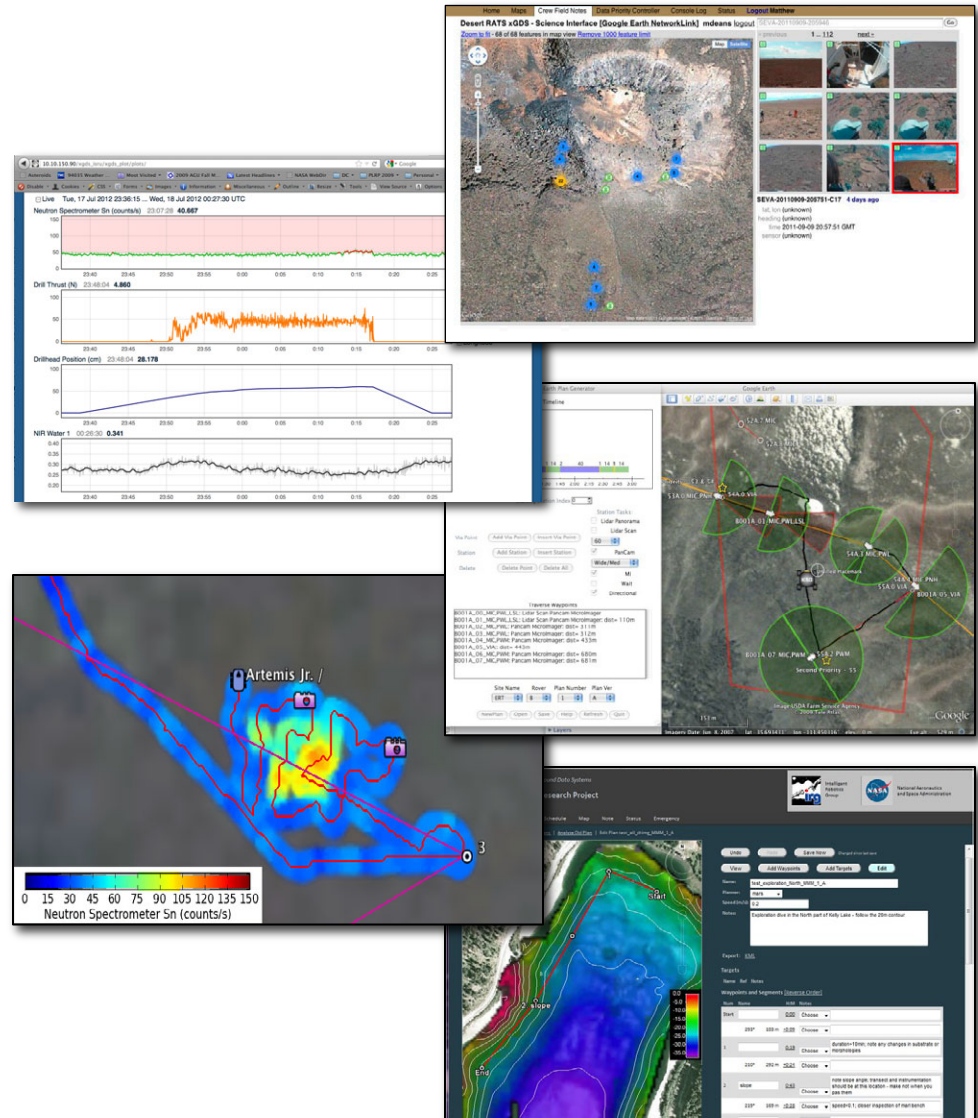| Tile Dimensions	256 x 256 pixels
Root Tiles / Image	15,000
Tile Space	25 KB
Tiles Total	229 million
Total Mosaic Size	5.7 TB

Exploration Ground Data System (xGDS)
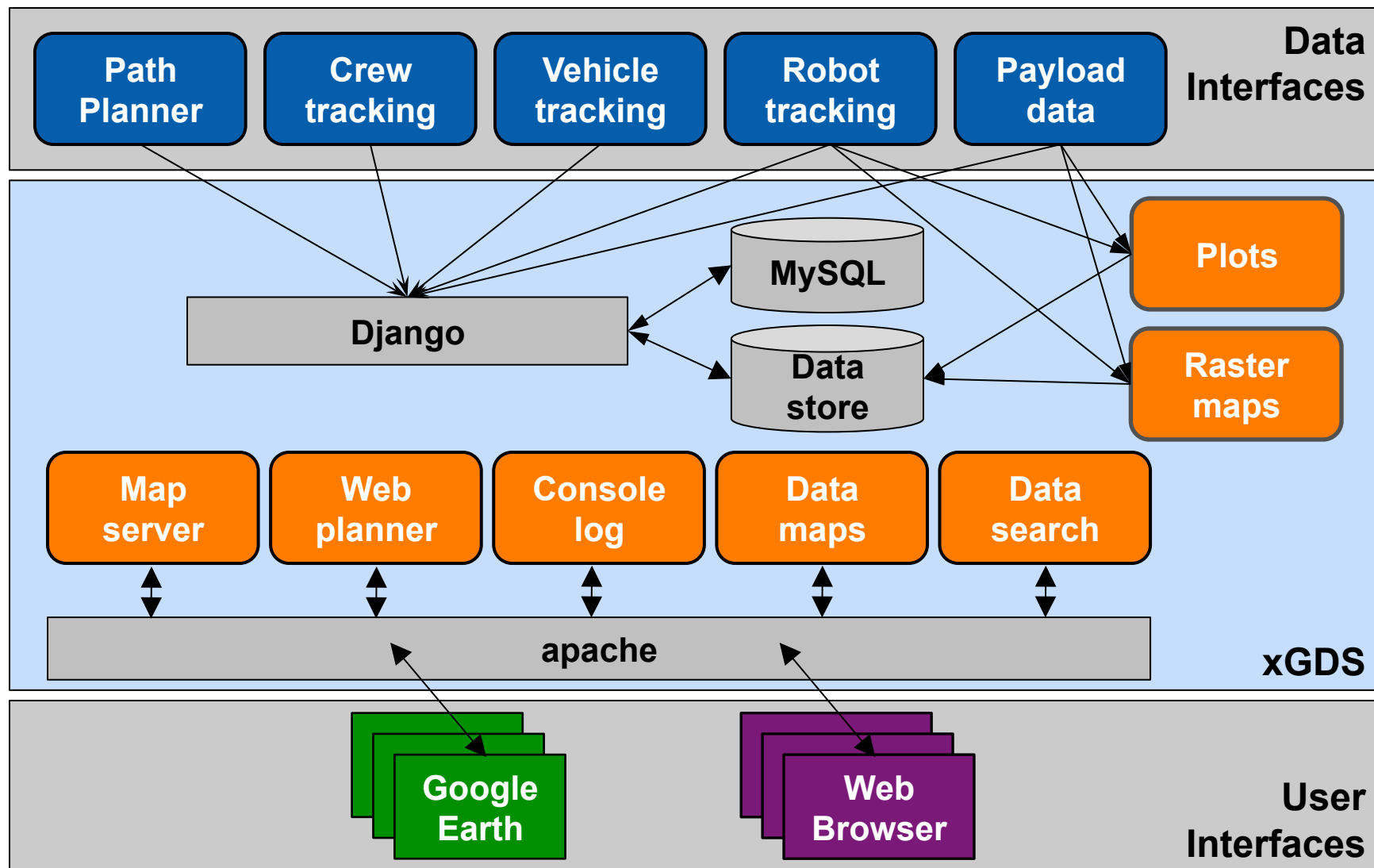
xGDS is …

- Map content management
- Planning tool
- Real-time plots, maps, notes
- Post-processing data archive
- Browse and search tools

Users

- Field scientists
- Planetary scientists
- Mission planners
- Flight controllers
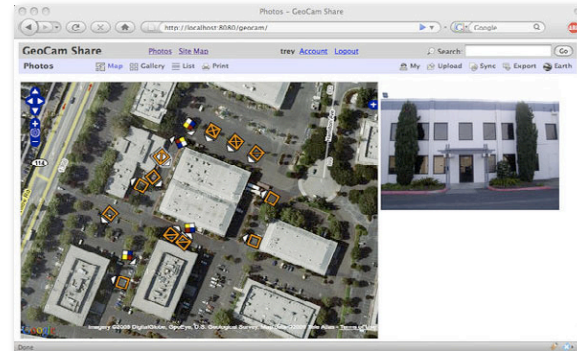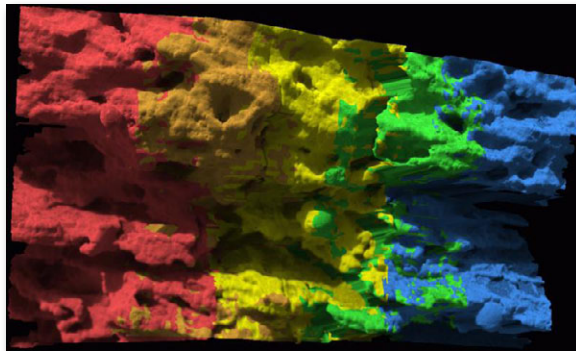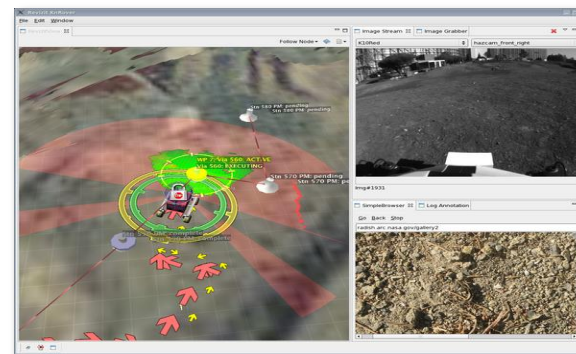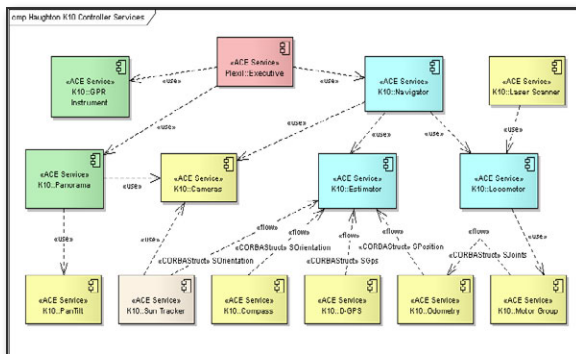- Local & distributed teams

xGDS Architecture

Data Interfaces

- Path Planner
- Crew tracking
- Vehicle tracking
- Robot tracking
- Payload data

xGDS

- Django
- MySQL
- Data store
- Plots
- Raster maps
- Map server
- Web planner
- Console log
- Data maps
- Data search
- apache

User Interfaces

- Google Earth
- Web Browser

IRG Open Source Software
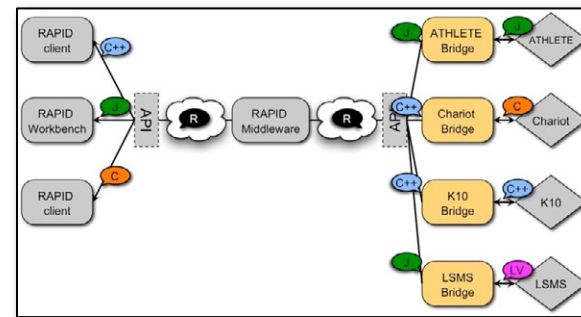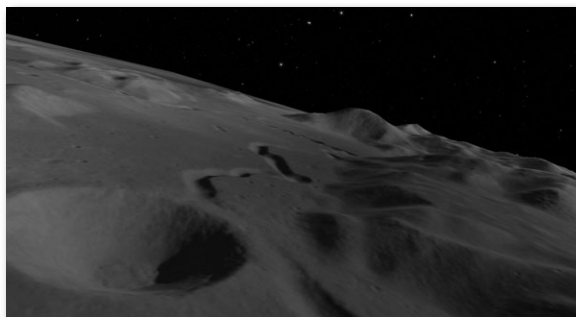

Vision Workbench

Exploration Ground Data Systems (**xGDS**)

RoverSW

Visual Environment for Remote Virtual Exploration (**VERVE**)

Neo Geography Toolkit
(with Ames Stereo Pipeline)

RAPID
(NASA robot middleware)

Questions?

Intelligent Robotics Group
Intelligent Systems Division
NASA Ames Research Center

irg.arc.nasa.gov